EGU General Assembly 2022

CL3.2.2: Towards a net-zero world: remaining carbon budgets, mitigation pathways, zero emissions commitment, and implications for policy

Mitigation scenarios for methane and nitrous oxide emissions from Indian agriculture sector

Omkar Patange[1,2], Pallav Purohit[2], Zbigniew Klimont[2], Amit Garg[1], and Vidhee Avashia[1]

[1]Public Systems Group, Indian Institute of Management, Ahmedabad, Gujarat, India (phd16omkarp@iima.ac.in)

[2]Pollution Management Research Group - Energy, Climate, and Environment Program, International Institute of Applied Systems Analysis, Laxenburg, Austria

This work is partly funded by European Union's Horizon 2020 research and innovation programme under grant agreement No 821471 (ENGAGE)

May 23, 2022
Virtual Presentation

Introduction

- Methane (CH_4) and nitrous oxide (N_2O) contributed to about a quarter of net anthropogenic CO_2eq emissions in 2019 (IPCC, 2021)
- India as fourth largest emitter with high growth rate, about 25% emissions from CH_4 and N_2O (MoEFCC, 2021)
- Major role of agriculture in non-CO_2 emissions – rice cultivation, livestock rearing, synthetic fertilizer use (MoEFCC, 2021)
- Socio-economic context – employs two-thirds of work force, 80% farmers own less than two hectares of land (MoA, 2018)
- Agriculture, predominantly rainfed, experienced reduced yields and crop failures in recent years due to changing climatic conditions (Carleton & Hsiang, 2016)

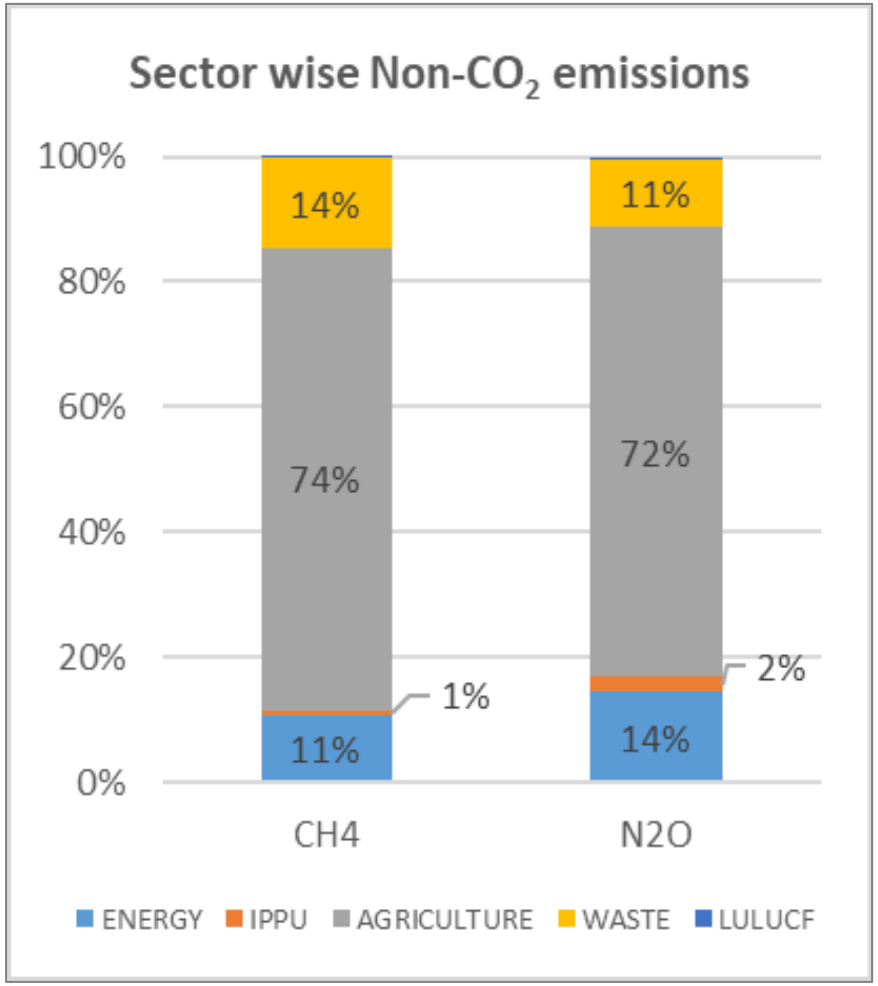


Illustration by authors, Data source: MoEFCC, 2021

Research objectives

- To project the methane (CH_4) and nitrous oxide (N_2O) emissions from key agricultural activities in India under the reference (REF) and alternate sustainable agriculture (SAS) policy scenarios
- To evaluate the maximum feasible reductions (MFR) potential of CH_4 and N_2O emissions through technological interventions in the agriculture sector under the REF and SAS scenarios
- To understand the possible synergies of the mitigation actions with social and environmental priorities in a given context

Methods and Data

- GAINS framework (Amann et al., 2011; Winiwarter et al., 2010)
- Emission Factors: IPCC Guidelines on National Inventory Management (2006), Government of India's biennial update report (BUR) to UNFCCC (BUR3, 2021)
- Model horizon: 2015-50
- Activity data: National agricultural statistics, FAO statistics, Livestock census, National sample surveys of farmers and farming activities
- Scenario drivers: Macroeconomic, demographic, sectoral policies

Scenario Architecture

	Technological intervention	
Structural intervention	REF	REF_MFR
	SAS	SAS_MFR

REF: Reference scenario, current sectoral policies relevant for mitigation of CH4 and N2O from agricultural activities, socio-economic and demographic drivers
REF_MFR: Maximum feasible reduction in REF through technological interventions
SAS: An integrated transition of agriculture sector to meet the social and environmental goals. For instance, reducing land under rice, sugarcane and other water intensive crops in water scarce regions.
SAS_MFR: Maximum feasible reduction in SAS through technological interventions

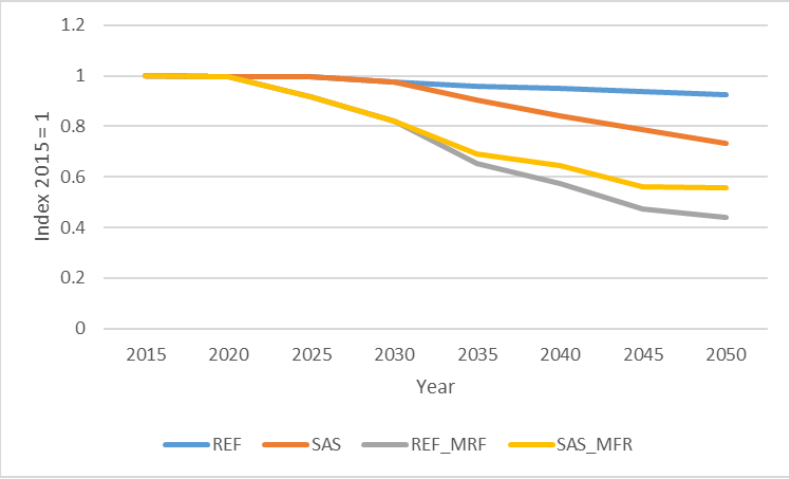
Current Policies in the agriculture sector

#	Mitigation Policy	Brief Description
1	Pradhan Mantri Krishi Sinchayee Yojana (PMKSY)	Replace flood method with micro-irrigation techniques
2	Crop Diversification Programme	Promote crop diversification to leguminous and other crops in water stressed, paddy cultivating states like Punjab, Haryana and Uttar Pradesh
3	System of Rice Intensification (SRI) and Direct Seeding of Rice	Reduce water use in paddy cultivation and reduce methane emissions in the process
4	Promotion of Nitrogen Inhibitors	Reduces N_2O emissions through inhibition of nitrification process in soil
5	Discourage Crop Residue Burning	Co-firing of biomass pellets in coal-fired plants, promotion of 2G biofuels using crop residue biomass (PM-JIVAN scheme)
6	National Biofuels Policy 2018	Achieve 20% ethanol blending with gasoline (EB20) by 2025. Government is diverting surplus sugarcane and cereals for ethanol production using first generation technologies
7	Artificial Insemination (AI) Program	Shift the herd composition towards in-milk animals and improve the milk yields
8	Manure Management	Ration Balancing Programme (RBP) to educate milk producing farmers on feeding balanced nutrition to their cattle. Bypass protein for animals to improve the access to high quality commercial feedstock with undegradable protein to the livestock
9	National Biogas and Manure Management Programme (NBMMP)	Subsidy and technological support for setting up family size biogas plants in rural households with livestock

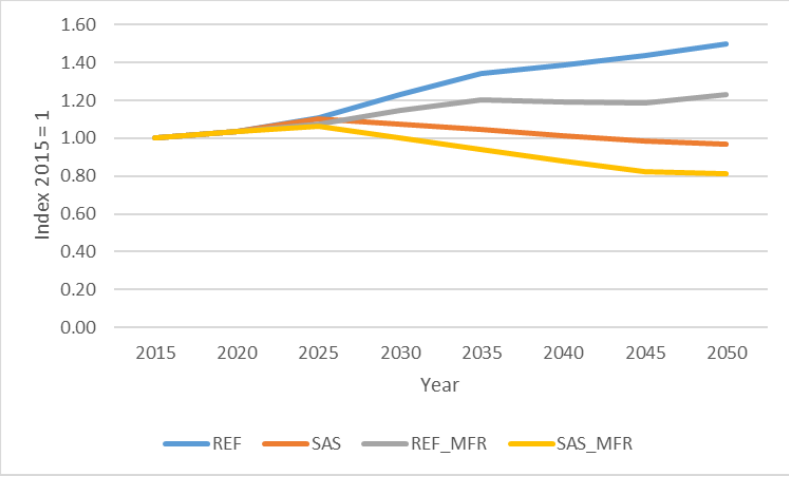
Source: Complied from MoEFCC, 2021 (BUR3) and other government reports

Results – Methane emissions

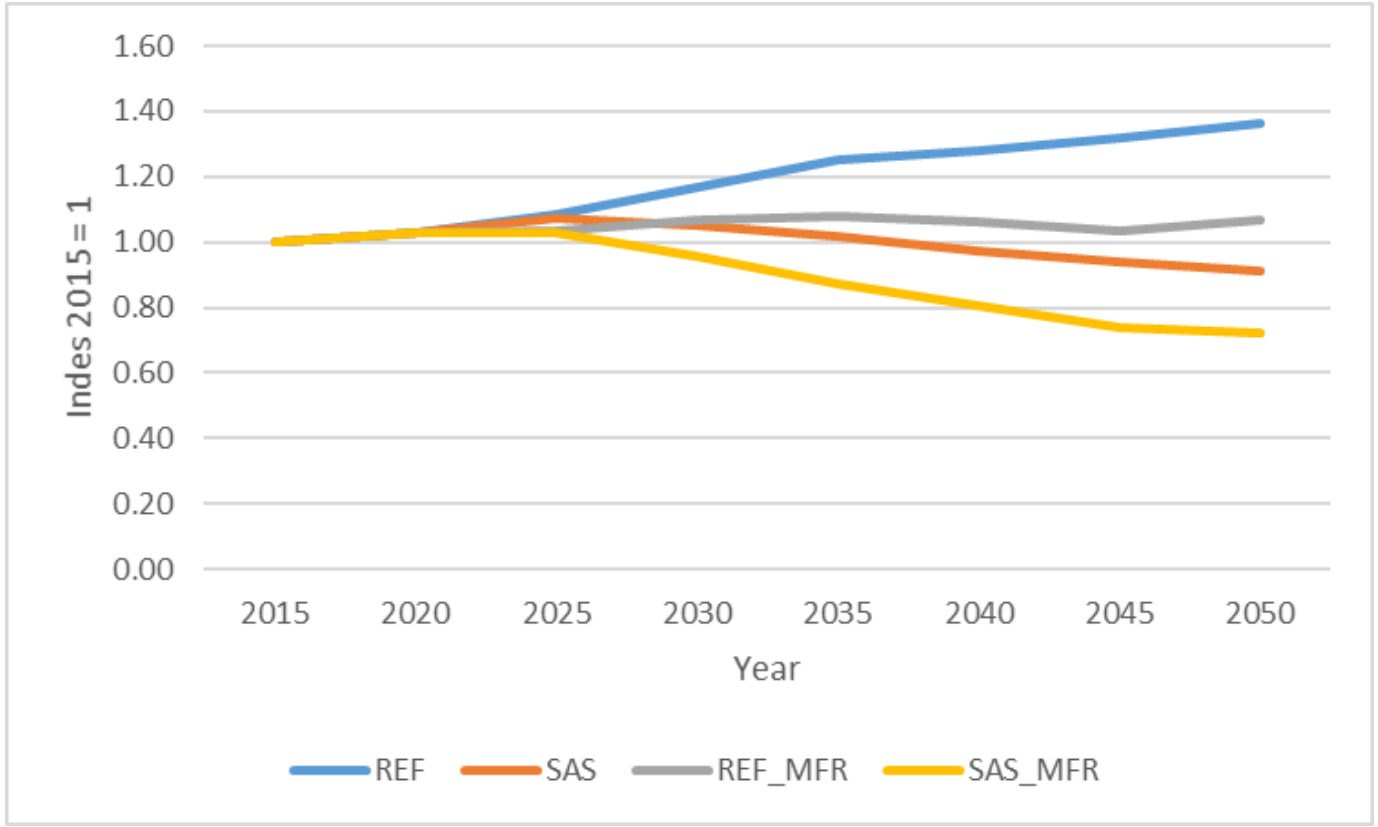
CH_4 projections from rice cultivation



CH_4 projections from livestock (enteric fermentation and manure management)



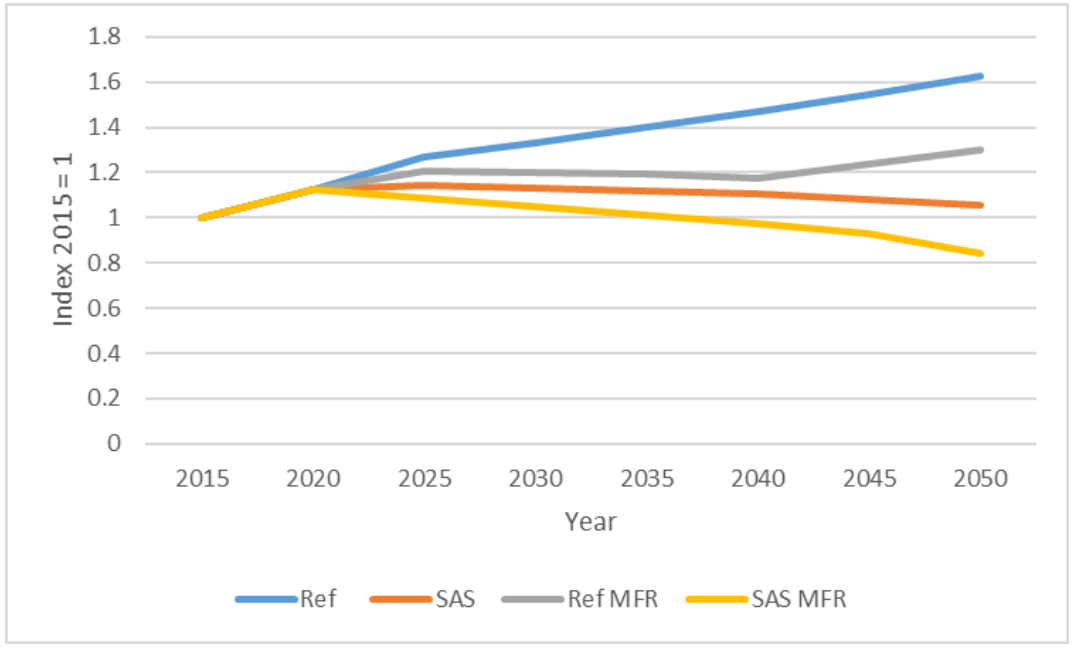
Overall CH_4 projections from agriculture sector



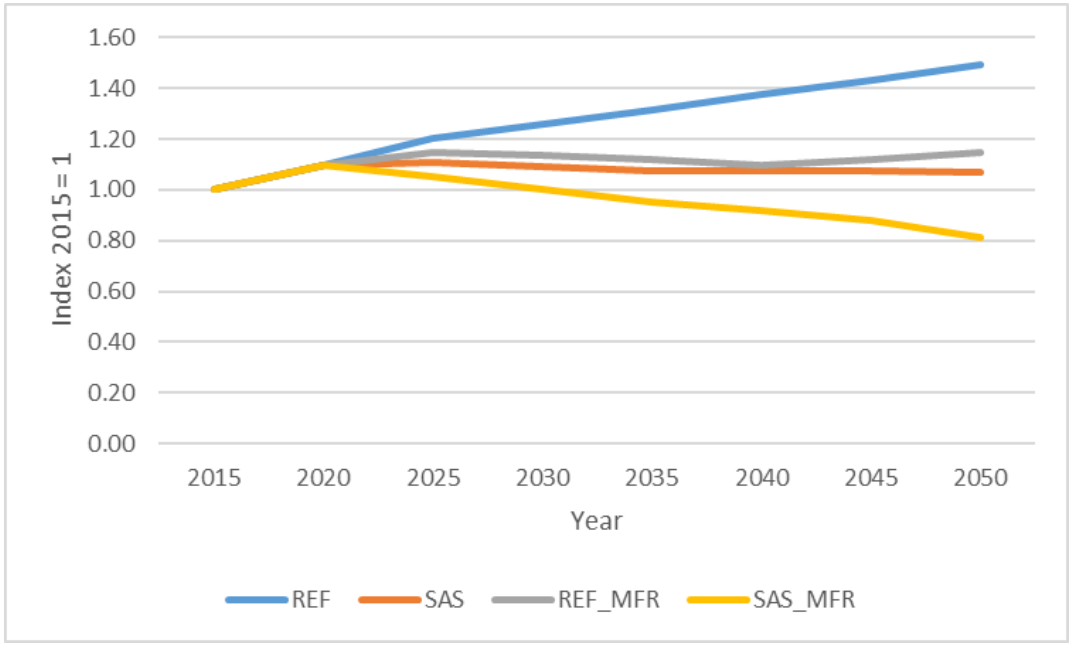
47% reduction projected between REF and SAS_MFR as compared to 21% between REF and REF_MFR

Results – Nitrous oxide emissions

N_2O projections from use of synthetic fertilizers



Overall N_2O projections from agriculture sector



46% reduction projected between REF and SAS_MFR as compared to 23% between REF and REF_MFR

Discussion and future scope

- Mitigation of non-CO_2 emissions from agriculture sectors requires a systemic approach to integrate social, environmental and climate goals
- Implications for air pollution – contribution of ammonia (NH_3) to PM2.5
- Action on water scarcity and biodiversity loss with synergies for climate action
- Synergies with food and nutrition policies, public health

Integrating technological interventions with the required environmental and social transitions in the agriculture sector could lead to deep reductions in non-CO_2 emissions from this sector

Thank you!

Omkar S Patange
phd16omkarp@iima.ac.in
patange@iiasa.ac.at

References

- Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., Klimont, Z., Nguyen, B., Posch, M., Rafaj, P. and Sandler, R., 2011. Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling & Software*, *26*(12), pp.1489-1501.
- Carleton, T.A. and Hsiang, S.M., 2016. Social and economic impacts of climate. *Science*, *353*(6304), p.aad9837.
- IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001
- IPCC, 2006: Guidelines for national greenhouse gas inventories. *Task Force on National Greenhouse Gas Inventories (TFI), Intergovernmental Panel on Climate Change*.
- MoA, 2018. Agricultural Statistics of India. Ministry of Agriculture and Farmers' Welfare, Government of India.
- MoEFCC, 2021. *India: Third Biennial Update Report to the United Nations Framework Convention on Climate Change*. Ministry of Environment, Forests and Climate Change, Government of India.
- Winiwarter, W., Höglund-Isaksson, L., Schöpp, W., Tohka, A., Wagner, F. and Amann, M., 2010. Emission mitigation potentials and costs for non-CO2 greenhouse gases in Annex-I countries according to the GAINS model. *Journal of Integrative Environmental Sciences*, *7*(S1), pp.235-243.